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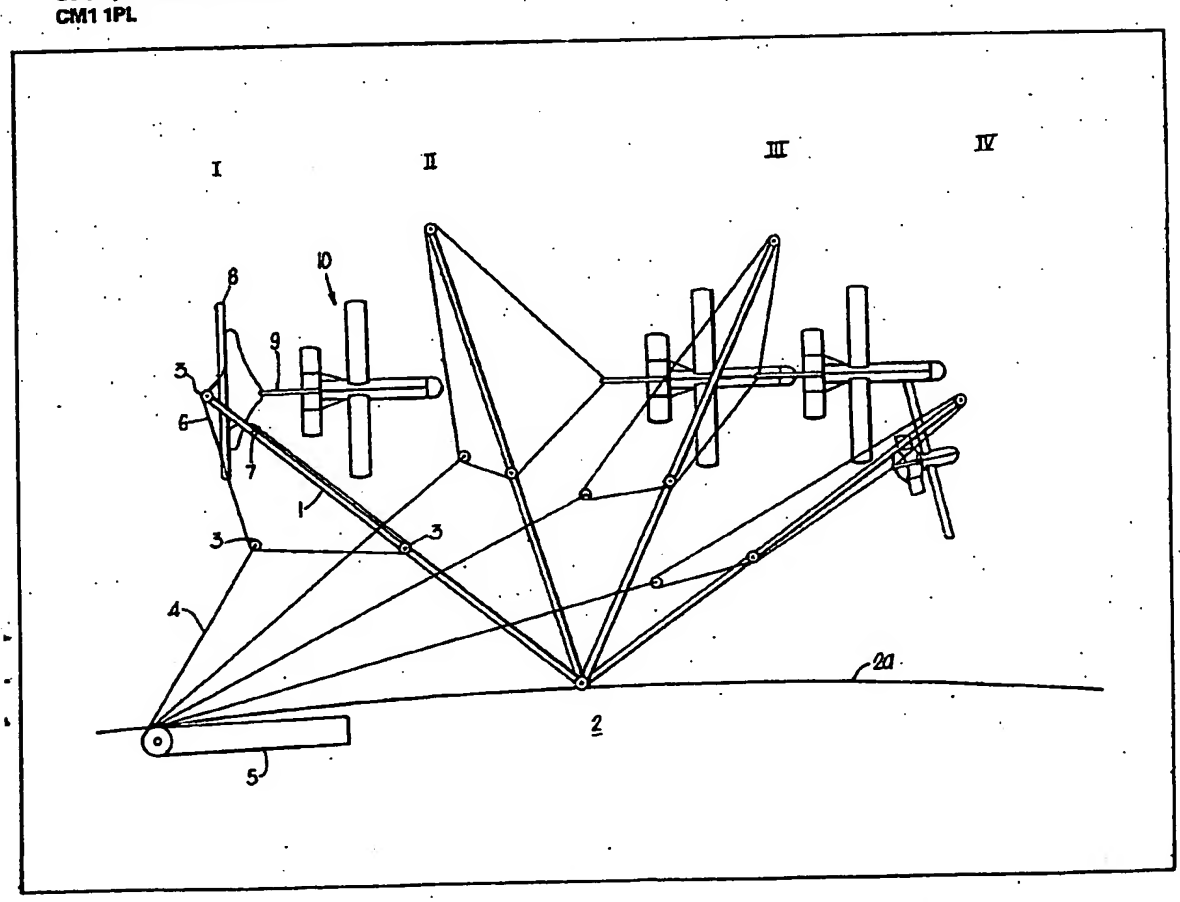
(54) Apparatus for use in the recovery of a flying object

(57) An apparatus for use in the recovery of a flying object, e.g. an unmanned aircraft to a ship, comprising a retardation wire (4) attached at one end to a braking device (5) and at the other end to an arrester means comprising a continuous wire loop (6) which runs around sheaves (3) on a pivoted boom (1) and a further sheave (3) attached to the end of the wire (4). A portion of the loop (6) extends horizontally across a semi-circular frame (8) fixed to the end of the boom (1) and it is this portion of the loop (6) which is enjoyed by a hook (9) on the aircraft (10). The loop (6) is then pulled away from the frame (8) and also from a releaseable toggle fastening (7) on the boom (1). The initial shock is taken up by the loop (6) moving around the sheaves (3) and then pulling on the wire (4) as the inertia of the boom is overcome. The boom swings around from positions I through IV, with the aircraft finally hanging underneath the boom, clear of the ship's side (2a).



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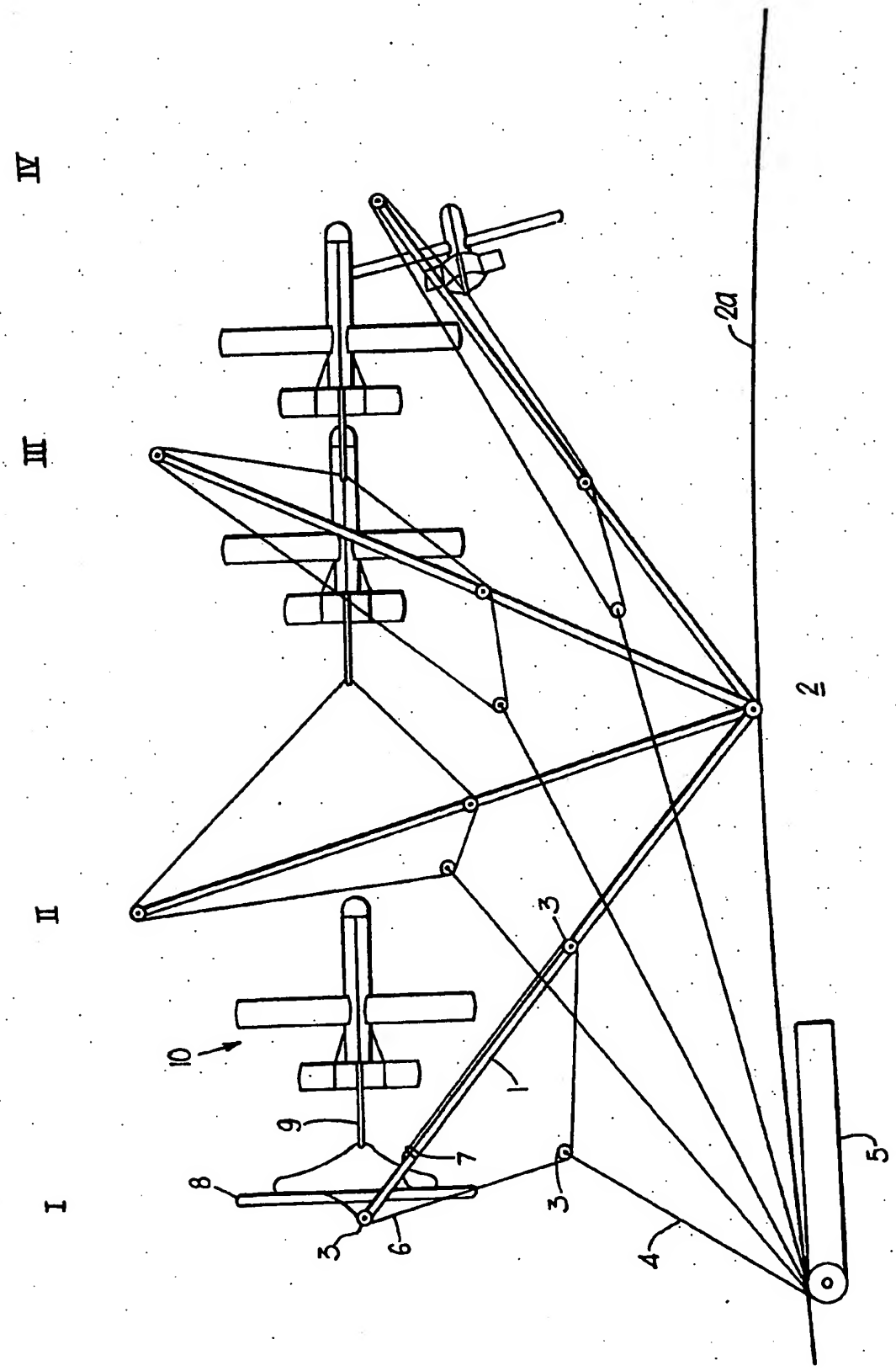
IV
III
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I
2a
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SPECIFICATION

Recovery of flying objects

This invention relates to apparatus for use in the recovery of flying objects such as unmanned aircraft, and particularly, though not exclusively, the recovery of such objects to ships.

Known methods of recovering unmanned aircraft to ships fall under one or other of four headings; controlled vertical landing; flight into a vertically disposed net; landing on an open deck; and parachute descent into the sea. Controlled vertical landing is only open to aircraft which can generate sufficient vertical thrust, e.g. helicopters. Flight into a vertically disposed net is successful only for aircraft of suitable configuration, e.g. narrow delta; for a straight winged aircraft the method has the severe disadvantage that high loadings are placed upon the wings and, since first encounter is likely to be at a point forward of the centre of gravity of the aircraft, the aircraft tends to tumble in retardation, resulting in a high probability of damage to the aircraft. For a fixed wing aircraft the space requirements for landing on an open deck are prohibitive and the piloting or control problems associated with this method are considerable; also, in the case of a missed recovery the probability of damage to the ship or injury to personnel is high. The disadvantage of the method of parachute descent into the sea include possible damage on impact, water contamination and the remaining problem of recovery to the ship.

It is an object of the present invention to provide an apparatus for use in the recovery of a flying object whereby the above difficulties may be overcome.

According to the present invention an apparatus for use in the recovery of a flying object comprises: a boom rotatably mounted at one end thereof; an arrester means attached to the other end of the boom and adapted to engage the flying object in recovery thereof; and retarding means for retarding rotational motion of the boom.

Typically, the arrester means comprises a wire adapted to engage a projection, for example a hook, on the flying object.

Preferably the retarding means includes a retardation wire attached at one end to a braking device and the arrester means comprises a continuous wire loop arranged to run around a plurality of guide members, one guide member being attached to the other end of the retardation wire and the or each other guide member being attached to the boom.

Preferably two said other guide members are provided which are attached to the boom at positions spaced along its length.

It will be appreciated that the term "wire" as used herein is not limited to one or more strands of metal, but also encompasses rope, cable etc., whether made of natural or synthetic material.

One apparatus in accordance with the invention will now be described, by way of example, with reference to the accompanying drawing which shows in plan view from above in four consecutive positions an apparatus for use in the recovery of an unmanned aircraft to a ship.

A boom 1 approximately 25 ft. long is attached at one end to the side 2*a* of a ship 2 so as to extend horizontally and rotate about a substantially vertical axis, and therefore in a horizontal plane, at a safe height above the sea. Two sheaves 3 are attached to the boom 1 at positions spaced along the length of the boom, one at the end of the boom remote from its attachment to the ship 2 and the other intermediate the two ends of the boom. A third sheave 3 is attached to one end of a length of retardation wire 4, the other end of which is attached to braking means 5 so as to act from a height above the plane of rotation of the boom 1. The braking means 5 may be a miniature version of the jigger type as used in aircraft carriers, a rotary fluid type brake, or any other suitable mechanism, as desired. Thus the speed at which the retardation wire 4 is paid out is retarded by the braking means 5. A continuous loop of arrester wire 6 is constrained to run around each of the three sheaves 3.

In preparation for the recovery of an unmanned aircraft the boom 1 is positioned at approximately 45° to the ship's side 2*a*, extending towards the general direction from which the unmanned aircraft will approach. Part of the loop of arrester wire 6 between the outermost sheave 3 and a releasable toggle fastening 7 intermediate the two sheaves 3 on the beam 1 is secured by releasable fastenings to a semicircular frame 8. The frame 8 is fixed to the end of the boom 1 so as to be positioned below the boom in a vertical plane perpendicular to the direction from which the unmanned aircraft will approach, the open-end of the frame being downmost so as to provide a horizontal portion of the arrester wire 6, some 8 feet long, perpendicular to the direction of approach.

Having prepared the apparatus for the recovery as described above, the recovery proceeds as follows. The ship need not be stationary and may be proceeding normally. It will be appreciated that the use of a boom makes compensation for the ship's motion a relatively easy process. The unmanned aircraft to be recovered is flown in unaccelerated straight and level flight on a course parallel with, or slightly divergent to, that of the ship. The unmanned aircraft is aimed approximately 2 ft. below the mid-point of the horizontal portion of the arrester wire, perpendicular to its length.

When the aircraft reaches the arrester wire, the horizontal portion of the wire engages a hook 9 on the aircraft 10 and the loop of arrester wire is pulled away from its releasable fastenings to the frame 8 and then from its toggle fastening 7 to the boom 1. At the position shown as I in the drawing the arrester wire has been pulled free of its fastenings to the frame 8 and is about to be pulled away from the toggle fastening 7. The frame 8 plays no further part in the recovery and is excluded from the further positions in the drawing in the interest of clarity.

The initial shock of engagement is taken up by the arrester wire loop 6 moving round the sheaves 3 and then (when the loop is evenly tensioned) pulling on the retardation wire 4 as the inertia of the boom is overcome.

As the inertia of the boom is overcome, it swings

to position II in the drawing and the arrester wire loop 6 runs clockwise (as seen in the drawing) around the sheaves 3 in response to the tendency of the unmanned aircraft to maintain its original flight path. Similarly, as the boom swings past its 90° position to position III in the drawing the motion of the arrester wire loop 6 reverses to become anticlockwise (as can be seen in the drawing).

Shortly after position III, the retardation wire 4 reaches the end of its travel and the unmanned aircraft, which has almost come to rest, begins to conform to the inboard swing of the boom. Since the retardation wire 4 can not extend any further, the continued motion of the boom (due to its own momentum and the momentum of the aircraft) serves to reduce the amount of the arrester wire loop 6 which is forward of the boom, thus bringing the aircraft up close to the boom. The aircraft and the boom therefore come to rest with the aircraft hanging underenath the boom, clear of the ship's side 2*a*, as in position IV. From this point the boom is swung inboard over the deck, where the unmanned aircraft is unhooked.

It will be appreciated that in a recovery operation as described above using an apparatus in accordance with the invention the bending moments applied to the boom are small and the effects of its inertia is also small. It will also be appreciated that by arranging the inboard point of action of the retardation wire, i.e. the braking device, above the plane of rotation of the boom, the downloads on the boom do not substantially exceed the static load applied by the weight of the unmanned aircraft.

It will also be appreciated that an apparatus as above described according to the invention displays the following advantages:

(i) Recovery of an unmanned aircraft using the apparatus does not interfere with normal deck operations;

(ii) The recovery apparatus occupies a small amount of deck space and is inexpensive, simple and easy to maintain;

(iii) The recovery apparatus is capable of retrospective fitting to a wide variety of ships;

(iv) Normal recovery of an unmanned aircraft using the apparatus does not involve damage to the aircraft; and

(v) In use of the apparatus, following a missed recovery there is a high probability of successful repeated attempt and low probability of damage to the ship or injury to personnel.

Also, in use of an apparatus as above described according to the invention recovery should be possible in wind speeds up to 30 knots from any direction.

It will also be appreciated that the boom may be used to guide an unmanned aircraft in launching.

It will also be appreciated that although the invention has been described heretofore as suitable for use in the recovery of unmanned aircraft, it could also be used in the recovery of manned aircraft, suitably modified.

CLAIMS

1. An apparatus for use in the recovery of a flying object comprising: a boom rotatably mounted at one end thereof; an arrester means attached to the other end of the boom and adapted to engage the flying object in recovery thereof; and retarding means for retarding rotational motion of the boom.

2. An apparatus according to Claim 1 wherein the arrester means comprises a wire adapted to engage a projection on the flying object.

3. An apparatus according to Claim 1 or Claim 2 wherein the retarding means includes a retardation wire attached at one end to a braking device and the arrester means comprises a continuous wire loop arranged to run around a plurality of guide members, one guide member being attached to the other end of the retardation wire and the or each other guide member being attached to the boom.

4. An apparatus according to Claim 3 wherein two said other guide members are provided which are attached to the boom at positions spaced along its length.

5. An apparatus according to Claim 4 wherein part of said wire loop is releasably secured to a frame fixed to the boom and positioned below the boom.

6. An apparatus according to Claim 5 wherein said part of the wire loop is between the one of said two other guide means further from the rotatably mounted end of the boom and a releasable fastening for the arrester wire between said two guide means.

7. An apparatus according to any one of Claims 3 to 6 wherein said guide means comprise sheaves.

8. An apparatus according to any one of Claims 3 to 7 wherein said boom is arranged for rotation substantially in a plane.

9. An apparatus according to Claim 8 wherein said plane is substantially horizontal and said braking device is positioned above said plane.

10. An apparatus according to any one of Claims 3 to 9 wherein the length of the retardation wire is such that in operation the retardation wire is fully extended before the boom reaches an extreme rotational position.

11. An apparatus for use in recovery of a flying object substantially as hereinbefore described with reference to the accompanying drawing.

12. An apparatus according to any one of the preceding claims arranged for use on a ship for recovery of a flying object thereto.

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